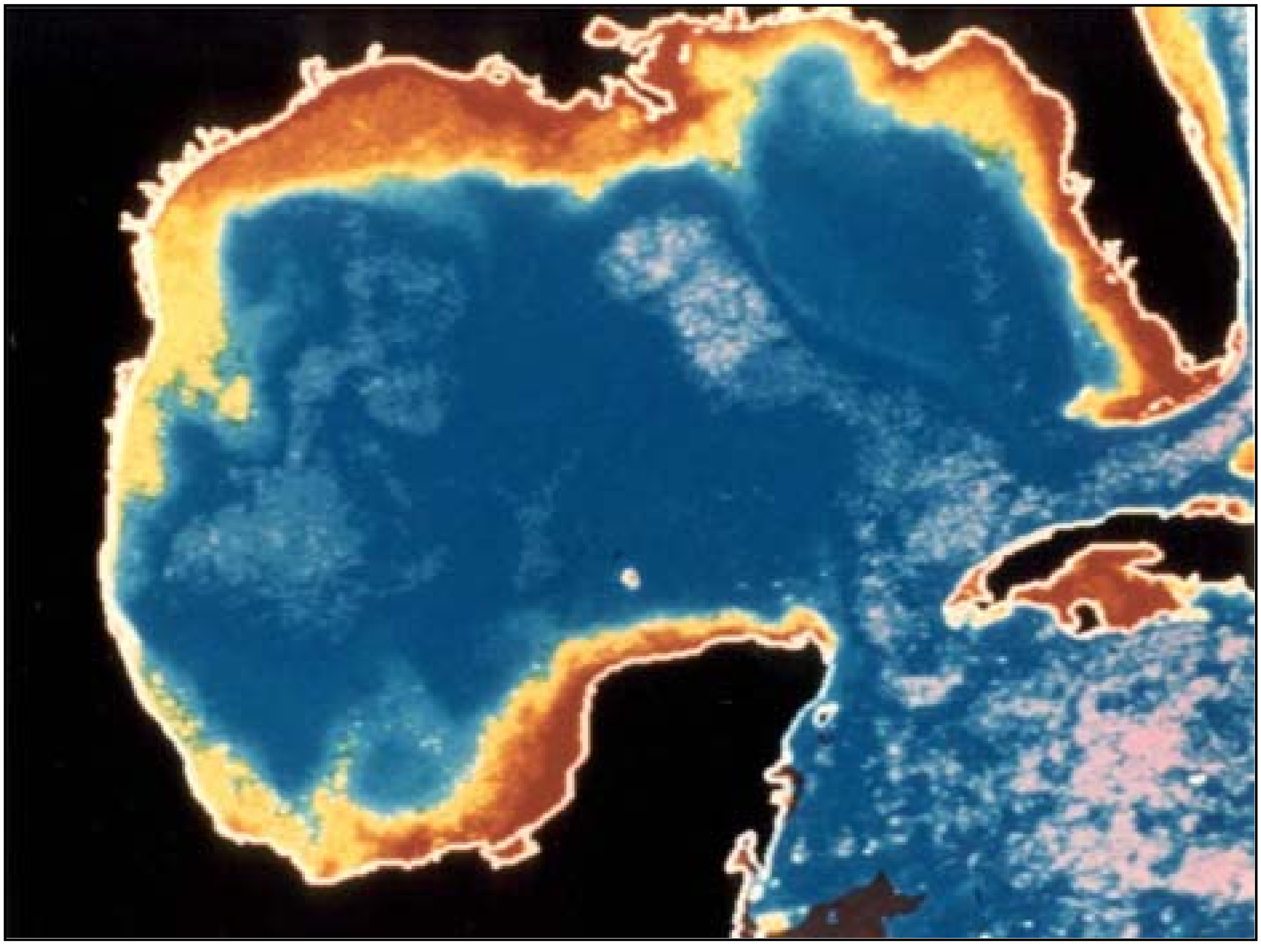
Remote Sensing Use and Needs in the Gulf of Mexico Coastal Region



Ad hoc Work Group on Remote Sensing
Monitoring, Modeling, & Research Committee
Data & Information Transfer Committee
Gulf of Mexico Program

REMOTE SENSING USE AND NEEDS IN THE GULF OF MEXICO COASTAL REGION

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Bldg. 1003, Room 202
Stennis Space Center, MS 39529

Submitted by:

Battelle
Coastal Resources and Ecosystems Management
938 Lafayette Street, Suite 101
New Orleans, LA 70113

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1.0 INTRODUCTION

The Gulf of Mexico Program (GMP) is a consortium of interests ñ Gulf State agencies, local governments, federal agencies, and non-government organizations ñ working to improve coordination and foster voluntary actions to restore and protect the Gulf of Mexico ecosystem. The GMP currently has four principal focus areas of work: public health, habitat protection and restoration, nutrient pollution, and invasive species. In addition, the Program is active in the areas of monitoring, modeling, research, information management, and public communication. The GMP Monitoring, Modeling, and Research Committee (MMRC) coordinates the monitoring, modeling, and research activities and requirements of the GMP Partners. The Data and Information Transfer Committee (DITC) coordinates information requirements, facilitates data sharing, identifies data needs in the Gulf region, and works to provide data to meet those needs via regional partnerships.

Remote sensing and Geographic Information System (GIS) technologies are increasingly being used to provide information and maps for analyses, management decisions, and presentations. Remote sensing imagery is a likely tool to provide or visualize indicators of the ecological condition of the Gulf of Mexico region. There may be a role for the GMP to purchase and distribute imagery and data as a potential user as well as to support the information needs of its Partners. The MMRC and DITC have organized an *ad hoc* Remote Sensing Work Group to establish a network of data users in the Gulf region that would help identify and coordinate needs, leverage resources, communicate new technologies, and share information and data. The Work Group is tasked with identifying the remote sensing requirements of the GMP Partners, especially the Gulf State agencies, and developing a strategy for meeting those requirements. The goals of the Work Group are to effectively use remote sensing as a monitoring, visualization, and assessment tool to support the goals and objectives of the GMP Partners, and to establish a continuing dialogue within the Gulf remote sensing community on remote sensing support required by the GMP Partners.

Two workshops were held to help the Work Group better understand current applications and limitations of remote sensing tools in the Gulf region and to initiate a dialogue with environmental managers in the five Gulf States on their use and requirements for remote sensing data. In addition, the NOAA Coastal Services Center (CSC) had completed a national evaluation of remote sensing requirements for coastal monitoring (NOAA 1999). The CSC evaluation indicated that remote sensing was an emerging tool being used more and more frequently to analyze coastal issues. The CSC provided its evaluation results for the Gulf Region to the Work Group. However, CSC data were designed to gauge technical needs and capabilities of natural resource managers, therefore the evaluationís broad scope provided limited data specifically addressing remote sensing requirements. Based on these results, it was decided that an additional evaluation of remote sensing uses and needs in the Gulf States was warranted.

This report synthesizes information found in that follow up evaluation. The Work Group will use the information in this report to develop a strategy for the GMP, where warranted, to help the Gulf States meet their needs for remote sensing imagery and data, and to encourage use of remote sensing as a valuable tool for environmental monitoring requirements at the State and Gulf-region levels.

2.0 METHODOLOGY

Members of the *ad hoc* Remote Sensing Work Group were contacted and given the opportunity to respond to a list of questions related to remote sensing applications in their organization (see Appendix A for the list of questions). Responses were solicited either by phone or e-mail. All study participants utilized remote sensing to address environmental issues in the Gulf of Mexico coastal region. Participants were asked to recommend other interview candidates. The study was intended to identify current uses of, and needs not being met for, remote sensing in the Gulf of Mexico region. The study also addressed the potential for partnerships within the Gulf region to fill the unmet needs. Open-ended questions were used so that the respondent could provide as much information as possible without having to fit their answer into a particular category. Responses were then collectively evaluated to discern themes and trends, and compared to those identified in the CSC study.

Table 1. Agencies Interviewed for the Study.

Mississippi Department of Environmental Quality (MDEQ)
Mississippi Department of Marine Resources (MDMR)
Louisiana Department of Natural Resources (LDNR)
Louisiana Oil Spill Control Office (LOSCO)
Louisiana Department of Environmental Quality (LDEQ)
Louisiana State University (LSU)
U.S. Geological Survey (USGS) in Louisiana
Alabama Department of Environmental Management (ADEM)
Baldwin County, Alabama, GIS Section
Geological Survey of Alabama (GSA)
Texas Natural Resources Information System (TNRIS)
Texas Parks and Wildlife Department (TPWD)
Texas Water Development Board (TWDB)
Southwest Florida Water Management District (SWFWMD)
Florida Fish and Wildlife Conservation Commission (FWCC)
Florida Marine Research Institute (FMRI).

3.0 RESULTS

Representatives of Gulf-region state and federal agencies, local governments, and universities (see Table 1) were interviewed during the period from January 30, 2001 to March 30, 2001. The list of individuals interviewed is presented in Appendix B.

Study findings (i.e., opinions of the interviewees) are presented in the following categories:

- Current uses of remote sensing in the Gulf region,
- Unmet needs for greater use of remote sensing, and
- The potential for partnerships within the region to fill the needs.

It was clear that terminology is critical when discussing remote sensing technology and its applications. Therefore, a glossary of remote sensing terms used in this study is provided in Appendix C.

3.1 Current Uses of Remote Sensing in the Gulf of Mexico Region

3.1.1 Coastal Issues Addressed with Remote Sensing

The NOAA CSC report stated that Gulf region agencies predominantly use remote sensing and GIS to obtain watershed management planning or assessment data and habitat mapping data. The GMP study posed a question to its participants that was similar to the one used in the CSC effort, however the GMP asked the respondents to identify current and future coastal issues that they hope to address with support of remote sensing and related tools. The participants reported that remote sensing tools are used most commonly for water quality and habitat mapping/restoration analyses. Approximately 69 percent of the participants reported using remote sensing imagery and data for water quality investigations, and 75 percent reported using remote sensing imagery for habitat mapping/restoration analyses (see Table 2), which agrees well with the findings of the CSC study.

Since the respondents represented all five Gulf States and a number of different organizations, specific applications of remote sensing varied immensely with the priority problems in the State and the priority objectives of the affiliated organization. All respondents reported that remote sensing is used widely in their state to investigate a range of coastal issues. In fact, the GSA and LOSCO indicated that their respective states use remote sensing to address all of the broad coastal issues provided as examples in the question (i.e., habitat, water quality, coastal development, and hazards). Furthermore, all respondents commented on the great number of potential remote sensing applications. Therefore the results presented in Table 2 do not represent all remote sensing applications, merely a subset of the most common applications biased by contacts made for this particular study.

For example, three remote sensing specialists in Florida participated in the study and each used remote sensing. The FMRI, a research institution, has a large number of remote sensing applications, including:

- Ecosystem Assessment
  - Habitat assessment and restoration (e.g., seagrasses)
  - Harmful algal blooms (e.g., red tides)
  - Environmental monitoring, assessment, characterization, and change detection
  - Endangered species

  - Environmental Sensitivity Index (ESI) mapping

- Fisheries Assessment
  - Fisheries biology
  - Fisheries assessment

- Hazard Assessment
  - Oil spill analysis

Table 2. Coastal Issues Addressed with Remote Sensing Tools.[1]

State	Agency (see Table 1)	Habitat	Water Quality	Coastal Development	Hazard Issues	Resource Management
Louisiana	LDEQ		X			
	LSU	X				X
	USGS	X	X			X
	LDNR	X				X
	LOSCO				X	
Florida	SWFWMD	X	X			
	FWCC	X		X		
	FMRI	X	X		X	X
Alabama	ADEM	X	X		X	X
	BALDWIN COUNTY	X	X			
	GSA	X	X	X	X	X
Mississippi	MDEQ		X			
	MDMR		X	X	X	
Texas	TNRIS	X	X	X	X	X
	TWDB	X		X		X
	TPWD	X	X	X	X	X

[1] This table represents respondentsí predominant applications of remote sensing technology, and not necessarily all applications of remote sensing for each organization.

The SWFWMD, a water resources management agency, utilizes remote sensing for specific applications such as seagrass and coastal spring mapping. The FWCC respondent reported serving more as a remote sensing image provider than a coastal manager using remote sensing analyses. Overall, remote sensing is predominantly used for assessing habitat and water quality issues, however it was apparent that its potential applications stretch far greater than its current use.

3.1.2 Current Remote Sensing Data Sources: Aerial Photographs and Satellite Images

Most of the participants reported that current uses of remote sensing technology are highly dependent on availability of appropriate datasets needed for their specific investigations. When asked about specific imagery, datasets, or tools that they use to address priority issues, they provided information on their sources for aerial photographs or satellite imagery. However, there are numerous remote sensing applications such as digital elevation maps and sea-surface temperature images that are also important for coastal investigations (Figure 1).

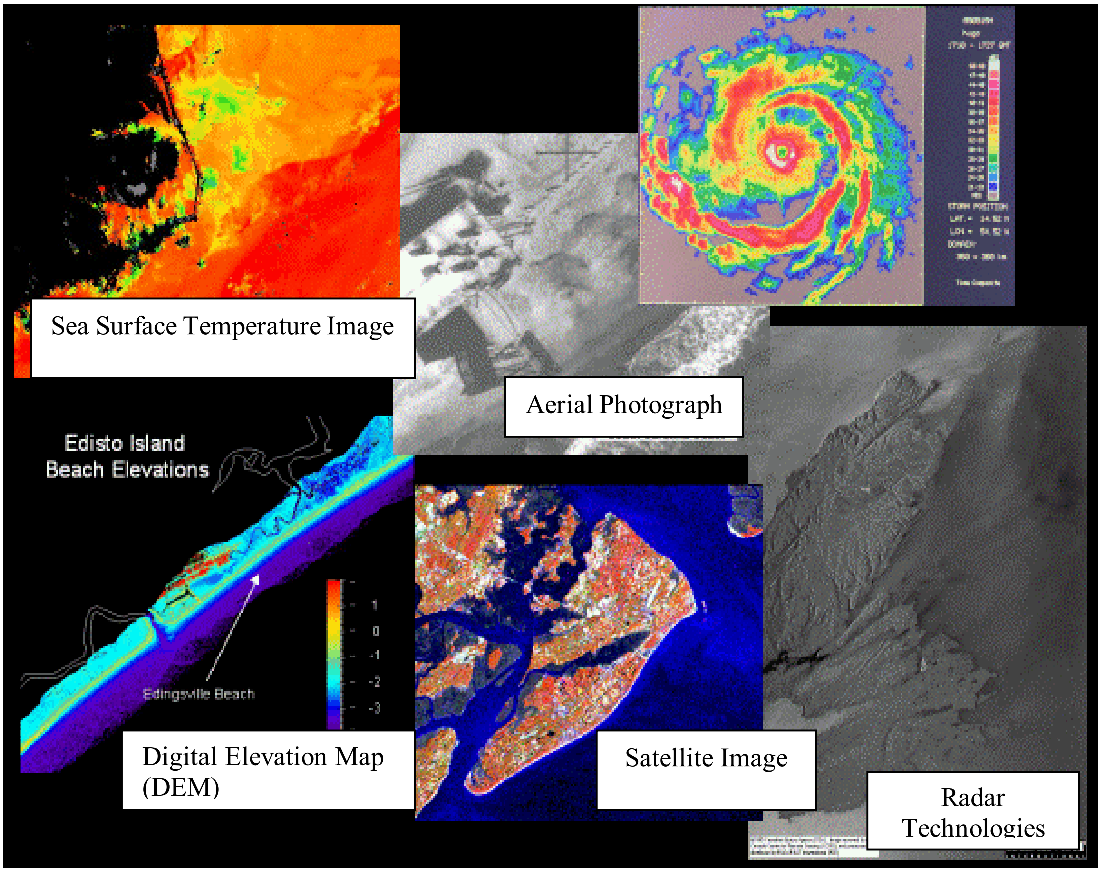

Image adapted from NOAA[1] 2001.

Figure 1. Examples of Remote Sensing Imagery Used in Coastal Investigations.

All participants who frequently use aerial photography highlighted the importance of partnerships to share the costs for adequate coverage of the coastal region. In fact, many Gulf States have a centralized agency responsible for maintaining and managing digital images for scientific analyses. While their approaches differ, each agency attempts to facilitate image sharing. For those respondents who predominantly use satellite imagery, in contrast to aerial photographs, most respondents indicated that the Landsat Thematic Mapper (TM) is the most commonly used source for these images (56 percent). However, satellite image processing and the extent of satellite image use varied from state to state. Data sources and development support for both aerial photographs and satellite images will be discussed in separate sections by state in order to identify the various data sharing and processing strategies employed throughout the Gulf region.

Aerial Photographs

ALABAMA: The ADEM and Baldwin County representatives both indicated that they predominantly rely upon aerial photographs for coastal investigations (ADEM 2001, Baldwin County 2001). Currently, the ADEM Coastal Programs Office attains a majority of their hard copy, aerial photographs from the Alabama Department of Conservation and Natural Resources (ADCNR). The ADCNR conducts regular overflights of the Gulf of Mexico shoreline from Mississippi to Florida. ADEM also works with the U.S. Army Corps of Engineers (USACE) to acquire true color aerial photographs, and the Mobile Bay National Estuary Program (MBNEP) and the GMP for future development of color infrared (IR) digital ortho quarter quadrangle photographs (DOQQs) of the Alabama coastline. DOQQs are a digital version of the traditional aerial photograph that are taken with IR light instead of normal light. Coastal managers like to work with DOQQs, instead of aerial photographs, because (1) DOQQ files can be easily compressed and downloaded over a standard Internet connection and (2) the digital images are georeferenced, which enables users to measure distances and positions on the image using GIS software (NCSU 2001).

In contrast, the Baldwin County GIS Section contracts with private companies for similar products such as true color photography (1:200), and color IR DOQQs. Baldwin County also has worked with ADEM on the development of color IR photographs of the Alabama coastline.

The GSA predominantly uses satellite imagery, thus no information pertaining to acquisition of aerial photographs was provided.

LOUISIANA: Louisiana state agencies, and one federal agency working in Louisiana (USGS), extensively rely on ìdata poolingî of aerial photographs. Respondents highlighted many major examples of partnerships within the state, which successfully accumulate and distribute aerial photography needed for coastal investigations.

The LDEQ, LDNR, and the USGS National Wetlands Resource Center (NWRC) procure photography of different portions of the state on a regular basis. LDEQ acquires photographs for the northern portion of the state for watershed studies, while NWRC and LDNR acquire imagery of the coastal regions (LDEQ 2001). These three agencies regularly share photographs, which results in coverage for a great percentage of the state.

A second example of data pooling within Louisiana includes a large state-federal partnership among seven different agencies that pool resources and money to develop and provide DOQQs to all interested parties. The aforementioned partnership acquires imagery and then makes it available to the public via the Louisiana Atlas web site (the Atlas web site facilitates GIS data and information sharing via the Internet, atlas.lsu.edu). Digital maps of the state are also available free on CD-ROMs from the Louisiana Applied and Educational Oil Spill Research and Development program which is described on the Atlas web site.

A third example of the use of partnerships for greater distribution of aerial photographs in Louisiana includes a recently signed Memorandum of Understanding (MOU) between several Louisiana state and federal agencies (Appendix D). Under the terms of this MOU, these agencies will take aerial photographs of the Louisiana coast prior to hurricane season and then take more aerial photographs immediately after a storm to provide information needed for damage assessments. LDEQ serves as the central repository for this annual photography (LDEQ 2001). This photography is available for a variety of other investigations as well.

FLORIDA: Respondents representing Florida agencies reported that partnerships and data pooling agreements are important for maximizing the use of aerial photographs. As in Louisiana, various state agencies regularly conduct overflights of key coastal regions for collection of aerial photographs. For example, the SWFWMD acquires photography of Tampa Bay, Sarasota Bay, and Charlotte Harbor to map seagrass beds every two years (SWFWMD 2001). Furthermore, the USGS National Aerial Photography Program (NAPP), in cooperation with the SWFWMD, acquires aerial photography (converted to DOQQs) over the entire water management district every 5 years. The NAPP is an interagency program specifically designed to maximize the use of government funds to attain photographs for multiple users in an attempt to eliminate duplicate efforts. Therefore, both the aerial photographs of the estuaries and the ortho-rectified images of the district are shared with all interested parties such as National Estuary Programs, FMRI, local governments, and universities. Acquisition of aerial photography in this case is not a joint effort between state agencies, as in some Louisiana examples, however data sharing does occur and provides greater access to a larger number of images.

MISSISSIPPI AND TEXAS: The States of Mississippi and Texas have centralized their acquisition of remote sensing imagery. Mississippi state agencies, such as the MDEQ, interpret data sets acquired and processed by the Mississippi Automated Resource Information System (MARIS). MDEQ does not have remote sensing technologies in-house, so they depend on MARIS to acquire and process the images for their agencyís needs (MDEQ 2001). Texas agencies such as the TPWD commonly use datasets procured and processed by the Texas Natural Resource Information Service (TNRIS). Instead of individually collecting and then sharing photography amongst agencies such as in Florida and Louisiana, Mississippi and Texas rely on the services of these centralized agencies to coordinate data purchases and process the data at these central facilities.

Satellite Imagery

Nine of the sixteen participants reported that they use Landsat TM data for their satellite imagery requirements. Landsat satellites have been providing repetitive global coverage of the earth for the last twenty years. The most advanced Landsat satellite, Landsat 7, collects seven bands of the electromagnetic spectrum and images an area approximately 185 feet by 170 feet with a spatial resolution of approximately 25 meters (NASA[1] 2001; Space Imaging Corp, 2001). Landsat TM data may not have the resolution required for some state activities, however the data are relatively inexpensive. Many state agencies can afford Landsat imagery and make use of its historical scenes for multi-temporal analysis. Several participants expressed frustration with the costs associated with higher resolution imagery (i.e., new 1-meter IKONOS imagery). Overall, the respondents indicated that imagery needed for their investigations were available, however high costs often prevented their use. A list of the latest sensors and platforms collecting applicable data that could be used if resources were available is provided in Table 3 with their relative spatial and spectral resolution information.

Table 3. Sensors and Platforms Collecting Images Applicable for Coastal Investigations.

Sensor/ Platform	Data Provider	Spatial Resolution	Spectral Resolution	Purpose
Modis	USGS/ NASA	250-1000-m	Thirty-six Multispectral Bands	Analysis and view of atmospheric, terrestrial, and ocean phenomenology
Landsat 7	USGS/ NASA	15-60-m	Seven Multispectral Bands, One Panchromatic Band	Land Use/Land Cover, Global Change Studies, Large Area Mapping
Indian Remote Sensing Satellite (IRS)	Euromap	5.8-188-m	Four LISS III Sensor Bands, two Wide Field Sensor Bands, one Panchromatic Band	Natural Resource Planning, Agriculture Monitoring, Natural Disaster Assessment
SPOT 4	SPOT Image Corporation	10-20-m	Four Multispectral Bands, One Panchromatic Band	Environmental Monitoring, Natural Resource Management
IKONOS	Space Image Corp.	1-m (Black/White), 4-m (Color)	Four Multispectral Bands, One Panchromatic Band	Land Use/Land Cover, Urban Planning, Agriculture Monitoring and Analysis, Mapping

Adapted from USU 2001

ALABAMA: The ADEM and Baldwin County indicated that they predominantly rely on aerial photographs for their investigations. The GSA respondent reported that they currently use Landsat TM data for land use/land cover classifications for the Alabama coastal area (AGS, 2001). The imagery is acquired from commercial vendors who apply value-added geometric and terrain corrections to the raw data. GSA has partnered with other agencies such as the U.S. Environmental Protection Agency (USEPA), the U.S. Department of the Interior Minerals Management Service (MMS), and the ADEM to share resources and pool funding to obtain imagery. The imagery and associated maps are used for management and decision-making applications by a variety of stakeholders, including many state agencies.

LOUISIANA: The five participants from Louisiana indicated that Landsat TM imagery is applied to a majority of their satellite imagery applications. LDNR also reported that they use higher resolution, SPOT panchromatic imagery (10-m spatial resolution) provided by the commercial vendor, Spot Image Corporation (LDNR 2001). Two of the respondents indicated that they would prefer to use higher spatial resolution imagery (such as IKONOS) or higher spectral resolution imagery, however associated costs were beyond their budget capability (LSU 2001, LDNR 2001). In efforts to increase resolution and accuracy, LDEQ and Dewitt Braud (LSU) recently merged Landsat data with Indian Remote Sensing (IRS) data to create a background color IR map with 5-meter resolution. All of the respondents identified numerous state and federal agency partners with whom they share datasets and results, and assist in data processing challenges. LDEQ noted that an annual Louisiana remote sensing workshop provides an opportunity for state experts to exchange ideas and technologies, and assists in maintaining state partnerships.

FLORIDA: One of the three respondents from Florida reported the use of Landsat TM images for generating vegetation maps. These images are classified by the FWCC and converted into vegetation/land cover maps that are then accessible to all interested parties (FWCC 2001). FMRI commonly uses Advanced Very High Resolution Radiometer (AVHRR) data for information pertaining to sea-surface temperature (FMRI, 2001). AVHRR data is collected by sensors emitting visible, near-infrared, and thermal-red spectrums (USGS[1], 2001). FMRI also uses Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) data for detecting chlorophyll-*a*. The SeaWiFS program collects, processes, and distributes data received from an Earth-orbiting ocean color sensor; ocean color data provides information pertaining to the various types and quantities of marine phytoplankton (NASA[2] 2001). The AVHRR data are received from University of South Florida's (USF) remote sensing laboratory and the SeaWiFS data are received from the NOAA CoastWatch Program through an agreement with Orbimage Corporation, a commercial image provider. The images are processed internally at FMRI. Other data are also obtained via collaborations with the Florida water management districts, and other state and federal agencies. The SWFWMD participant implied that they use aerial photography for most applications.

MISSISSIPPI: As mentioned above, MSDEQ acquires most of its images from MARIS. However, other Mississippi state agencies, such as the MDMR, use imagery from a relatively large number of different satellite sensors. MDMR acquires these images predominantly to investigate coastal zone management (CZM) issues such as development, land use planning, and change detection (MDMR 2001). Their sources of data include:

- Landsat imagery from USGSís Earth Resources Observation Systems (EROS) Data Center;
- Aerial Remote Sensing Imagery from the NASA Commercial Remote Sensing Program (CRSP);
- Side scan SONAR imagery collected by from agency research vessels; and
- Coastal Radar (CODAR) electromagnetic imagery, which is used to measure surface currents, waves, and circulation, patterns (Rutgers 2001).

TEXAS: Texas state agencies also use a wide variety of satellite imagery for coastal investigations. TPWD uses the following remote sensing imagery, acquired predominantly from TNRIS or Texas Synergy (another state remote sensing initiative), to investigate water quantity, water quality, habitat change, and hazard issues (TPWD 2001):

- MODIS data;
- SeaWiFS data;
- AVHRR data;
- Landsat TM data;
- Panchromatic Images fused with Multispectral Images;
- Light Detection and Ranging Technology (LIDAR) data which uses laser pulses to produce elevation contour maps associated with digital elevation models (Airbornelasermapping.com 2001; NOAA[2] 2001); and

- Commercial panchromatic or multispectral data from Spot Image Corporation.

3.2 Current Remote Sensing Limitations in the Gulf of Mexico Region

Current remote sensing applications discussed above are limited by a number of factors. The participants identified the following major barriers and unmet needs preventing greater expansion of remote sensing applications for coastal investigations in the Gulf region (Table 4). Specific equipment and data requests are summarized in Table 5 and Table 6, respectively, and discussed in more depth in the following text.

Table 4. Common Remote Sensing Barriers and Unmet Needs for Remote Sensing in the Gulf Region.

Most Common Barriers/Unmet Needs	Organization
Lack of staff/Funds for staff time	GSA, LOSCO, FMRI, FWCC, TPWD, TWDB, Baldwin County, TNRIS, ADEM
Cost of high resolution data/Funds for data purchasing [1]	GSA, LOSCO, LDNR, FMRI, MDMR, MDEQ
Inadequate hardware and software/Tool acquisition and maintenance funds [2]	GSA, Baldwin County, ADEM, TNRIS, USGS, LDNR
Inability to complete field validation, groundtruthing, and georeferencing	LSU, FMRI, SWFWD, TWDB
Costs associated with data processing	FMRI, MDMR
Inconsistent data among states and comparable to historical information	USGS, FMRI
Coordinating partnerships for data acquisition and methodology collaboration	ADEM, FMRI

[1] See Table 6 for Specific Data Requests
[2] See Table 5 for Specific Hardware Requests

Table 5. Specific Hardware and Software Requests by Participants.

Specific Hardware/Software Requests	Organization
Ability to transmit large images over the Internet	TNRIS, Baldwin County
Server space	ADEM
Plotters	ADEM
Averaging tool for AVHRR and SeaWiFS Data	FMRI
Visualization tool for specialized formats such as HDF: NOeSYS	FMRI
Visualization Pro	FMRI

Table 6. Data Requested by Gulf Region Organizations.

Specific Data Requests	Organization
High resolution imagery (IKONOS or IRS)	LSU, LDNR, MDMR, FMRI, LOSCO, SWFWMD
More Color IR DOQQs	USGS, FWCC, TWDB
Color IR Photography of Gulf of Mexico Bays, Estuaries and Near Coastal Water	TWDB
Multi-temporal imagery	LSU, MDMR
LIDAR DEMS	SWFWMD, MDMR
Hyperspectral images that identify roadways or tanks	LOSCO
High resolution elevation data	LOSCO
Aerial photographs for habitat maps	USGS
Imagery for riparian areas	TPWD
Imagery for water quantity	TPWD
Satellite wind data: ERS-1, NSCAT	FMRI
Satellite derived ocean current data	FMRI
Funds to redigitize updated raster images	LOSCO
High resolution thermal data map	SWFWMD
Addition research on algorithms to interpret more from Landsat images	FWCC
Bathymetric mapping	SWFWMD
Value-added remote sensing imagery (geocoded, mosaicked, atmospherically corrected)	MDMR
Imagery for stream conditions[1]	MDEQ
Imagery for water pollution[1]	MDEQ
Imagery for land use/land cover annually at Mississippi Delta[1]	MDEQ

[1] Top aquatic priorities identified at a group brainstorming and prioritization session held between NASA and MDEQ. Full results in Appendix E.

3.2.1 Barriers to Uses of Remote Sensing

ALABAMA: ADEM and Baldwin County both lack the appropriate equipment (*i.e.* server space, plotters, slow connections, etc) to use remote sensing in a greater capacity. ADEM mentioned that their equipment problems should be solved shortly, however they also had difficulty obtaining necessary data from various state agencies. They are currently working on that process, although many users are reluctant to distribute data that they initially purchased. In addition to inappropriate equipment, the Baldwin County representative mentioned that they lack adequately trained staff to make map products and models.

The basic hardware and software assets plus the required expertise are already in-house at the GSA. However, the GSA lacks adequate funding for staff time, software and hardware maintenance, and acquisition of data (GSA 2001).

LOUISIANA: The Louisiana participants indicated that the major barriers preventing greater use of remote sensing include:

- The costs associated with the high resolution satellite and privatized data (LOSCO 2001, LDNR 2001);
- The lack of experienced staff needed to process the data (LOSCO 2001);
- Inconsistent data sets between states (USGS[2], 2001);
- Finding needed data, downloading from the Internet, and computer storage (USGS[2] 2001, LDNR 2001);
- Limited interpretation abilities of images; field validation is required (LSU 2001); and
- Convincing managers of the validity of results for management decisions (LSU 2001).

FLORIDA: The Florida participants identified the following barriers to greater use of remote sensing technology:

- Inconsistent formats of remote sensing products (FMRI 2001);
- Correlating coordinates with new, high resolution data (offshore data not being geo-referenced) (FMRI 2001, SWFWMD 2001);
- Data costs (FMRI 2001);
- Time and associated cost to develop techniques and process data (FMRI 2001);
- Limited number of staff and funding for staff (FMRI 2001, FWCC 2001);
- High costs of previous projects that did not produce significant products (FMRI 2001);
- Difficulties in defining roles in collaboration and sharing imagery and methodologies (FMRI 2001); and
- Limited number of DOQQs needed to refine the remote sensing images (FWCC 2001).

MISSISSIPPI: The MDEQ participant provided the results of a group brainstorming and prioritization session, held in association with NASA, to identify remote sensing needs in the State of Mississippi. The meeting summary is presented in Appendix E. She also indicated that a major barrier for greater use of remote sensing is lack of funding to contract out their projects:

MDEQ does not have adequate remote sensing capabilities in-house, however they lack the budget to outsource all of the needed projects (MDEQ 2001).

MDMR identified the following barriers to greater use of remote sensing technology (MDMR 2001):

- Costs associated with data processing;
- Costs associated with higher spatial and spectral resolution data, dependence on inexpensive, less accurate data such as Landsat, CODAR (federal partner), and side scan SONAR (in-house capability).

TEXAS: The Texas participants indicated that the major barriers preventing greater use of remote sensing include:

- Lack of support staff available to help the public take advantage of the available data (TNRIS 2001);
- Difficulty involved in image sharing since the images have large bandwidths that cannot be transferred over the internet (TNRIS 2001);
- Inadequate number of staff (the state mandates their hiring practices) (TPWD 2001);
- Cost of staffing and funding limitations (TWDB 2001); and
- Availability and access to groundtruthing (TWDB 2001).

3.2.2 Unmet Remote Sensing Needs

ALABAMA: Both ADEM and Baldwin County indicated again that lack of appropriate equipment and properly trained staff are areas where they need improvement to enable them to use remote sensing more effectively (ADEM 2001, Baldwin County 2001). GSA identified the following unmet remote sensing needs:

- Program development funds, both general and project specific, from a broader group of partners;
- Data acquisition funds;
- Tool maintenance funds.

LOUISIANA: The Louisiana participants identified the following unmet remote sensing needs:

- Accessible raster data sets from the IKONOS Satellite (LOSCO 2001);
- Vector data sets recently digitized that will be compatible with new raster data (LOSCO 2001);
- Hyperspectral images with two-meter horizontal accuracy or better (LOSCO 2001);
- High resolution imagery (LSU 2001);
- High resolution imagery at five-meter resolution or better (LDNR 2001);
- High resolution elevation data with vertical accuracy of three inches (LOSCO 2001);
- Multi-temporal imagery (LSU 2001);
- Consistent data across the Gulf region (USGS[2] 2001); and

- More aerial photographs for habitat mapping (USGS[2] 2001).

FLORIDA: The Florida participants identified the following unmet remote sensing needs:

- IKONOS satellite data for benthic mapping, seagrass monitoring, evaluating health of benthic communities, benthic community density/biomass determination (FMRI 2001);
- Averaging tool for sea surface temperature (AVHRR) and ocean color (SeaWiFS) data;
- Satellite wind data (daily, weekly monthly) ERS-1, NSCAT (FMRI 2001);
- Satellite-derived ocean current data (FMRI 2001);
- Visualization tool (PC) for specialized formats such as HDF: NOeSYS Visualization Pro (FMRI 2001);
- High resolution, thermal data to map offshore coastal springs (SWFWMD 2001);
- More accessible, low cost satellite imagery (SWFWMD 2001);
- LIDAR technology to map surface elevation basins to identify flood zones (SWFWMD 2001);
- Inexpensive ways to attain higher resolution bathymetric data (SWFWMD 2001); and
- Improved algorithms to bring more information out of Landsat data for better identification of land cover types (FWCC 2001).

MISSISSIPPI: See Appendix E for the results from the NASA-MDEQ meeting regarding unmet remote sensing needs in Mississippi. The MDMR participant indicated that they needed the following data sets for better use of remote sensing technology for CZM applications:

- Seasonal imagery;
- LIDAR-derived Digital Elevation Models (DEMS) for the coastal zone; and
- Higher spatial resolution imagery with sufficient spectral resolution.

TEXAS: The Texas participants identified the following unmet remote sensing needs:

- Support for public use of available data (TNRIS);
- Affordable data (TNRIS);
- Experienced staff (TPWD);
- Water quantity data sets (TPWD);
- Riparian areas data sets (TPWD);
- Wider range of parameters that can be measured (TWDB); and
- Ground-truth data (TWDB).

3.3 Potential for Partnerships to Fill Current Needs

ALABAMA: Within Alabama, the GSA collects, develops, and disseminates a majority of the stateís digital geographic information related to natural resources. As noted above, the GSA lacks sufficient funds to better develop their program and their data collection. Therefore, other state agencies requiring imagery not provided by GSA have formed partnerships. For example, ADEM already partners with several agencies to attain aerial photographs.   Alabama state representatives all agreed that more partnerships would provide additional resources to acquire more imagery.

LOUISIANA: Although there are currently several ìdata-poolingî partnerships within Louisiana, all of the respondents indicated that more partnerships would only enhance data availability, particularly for attaining more aerial photographs and DOQQs (USGS[2] 2001, LDNR 2001). LDEQ also highlighted the success of a recent annual remote sensing workshop held within the state. They noted that the workshop provided the stateís users with an opportunity to exchange ideas, which seems to foster better information sharing and future partnerships.

FLORIDA: There is data sharing between state agencies, but no central repository, as in Mississippi and Texas. Florida respondents indicated that more partnerships may be helpful to share acquisition costs for aerial photographs, however the SWFWMD respondent did note that formal partnerships do sometimes cost more money in contracts than they may be worth (SWFWMD 2001). He advocated informal partnerships that would involve open communication and data sharing between the agencies. FMRI respondents pointed out that partnerships are currently forming in Florida to attain AVHRR and SeaWiFS imagery between the FMRI, USF, and USGS (FMRI 2001).

MISSISSIPPI: MARIS is clearly the result of a major partnership within Mississippi state agencies to create a centralized data repository for GIS and remote sensing imagery. MARIS maintains, builds, and enhances all of the digital spatial data for the state. The Mississippi participants indicated that they were not sure how a multi-state partnership would function, since they are not aware of other stateís needs. However, MDMR did indicate that a regional acquisition program might help reduce costs (MDMR 2001).

TEXAS: Similar to Mississippi, the Texas Geographic Information Council created TNRIS to act as the State's clearinghouse and data purchaser for natural resources data. TNRIS represents more than a dozen member agencies, and demonstrates the effectiveness of partnerships within Texas. TNRIS distributes USGS maps and has numerous other map collections available pertaining to water resources, geology, census, and other natural resources-related spatial data.

Respondents highlighted two further ways in which partnerships may be effective in Texas. The TPWD respondent suggested that partnerships with commercial vendors would prove advantageous to the remote sensing community (TPWD 2001). Currently, state agency users are limited in their data purchases due to licensing restrictions from commercial vendors. Commercial vendors often have the more advanced, refined images, thus state users would like greater access to their imagery (TWDB 2001).

The TWDB participant indicated that partnerships might assist in attaining more color, infrared aerial photographs of Gulf of Mexico bays, estuaries, and near coastal waters.

4.0 SUMMARY OF FINDINGS

Remote sensing has greatly improved the abilities of coastal managers to monitor and evaluate both natural and anthropogenic changes within coastal zone and offshore marine areas. It is clear that coastal managers in all five Gulf States are using remote sensing, however, there are extensive opportunities to expand the use of remote sensing that remain unmet.

Currently, the most common remote sensing technologies used for Gulf region coastal investigations include aerial photographs and satellite imagery. However, remote sensing users also indicated that they use CODAR, side scan SONAR, LIDAR, and myriad other remote sensing technologies. The two most commonly identified barriers preventing greater use of these technologies included a lack of staff and insufficient data.

Many participants reported that they were not able to update or process their data effectively because of a lack of funds for staff time (most participants noted that their remote sensing users also have a number of other responsibilities). Centralized organizations such as MARIS or TNRIS are comprised of trained remote sensing specialists that may provide remote sensing services if funds are available for agencies to contract work out to these specialists. It may benefit each state, and respective state agency, to determine if their funds are used most efficiently if they conduct all their remote sensing analyses in-house or if they contract all of their remote sensing analyses out to a centralized agency (in states where this is an option). If each state chooses one of these strategies, then staff problems would hopefully be resolved in accordance to the chosen structure. For training and information dissemination purposes amongst staff, annual workshops have been an effective way for various remote sensing users to discuss the fieldís latest developments in Louisiana. Annual workshops are especially important in those states where remote sensing is conducted at individual agencies, therefore they are not interacting and exchanging information on a regular basis.

Participants also frequently mentioned difficulties in data acquisition and sharing as a barrier preventing greater use of remote sensing technologies. Those coastal managers who depend on aerial photographs and DOQQs for their coastal investigations indicated that partnerships and data pooling were used extensively to access the necessary images. However, many representatives still indicate that they would like access to more DOQQ photographs. Louisianaís website appears to provide needed DOQQs to all interested parties, therefore those state agencies indicating that they have inadequate digital imagery might look into a similar effort to post all available state DOQQs on a web site for better dissemination throughout the region.

Data acquisition and sharing is not as easy for satellite imagery. New, higher spatial resolution and higher spectral resolution data have come onto the market from new satellites and commercialized sources. To enhance accuracy, state agencies would like to use these images, however high prices limit purchasing ability. Participants reported that it is more difficult to pool money for acquisition of commercial imagery due to licensing restrictions that might prevent image sharing. However, commercial data providers for IKONOS and IRS imagery indicated that they could provide government agencies multiple-use licenses that allow the agency to share the imagery with other branches of the government. Specifically, the provider of IKONOS data, Space Imaging Corporation, indicated that government agencies could establish a flexible license through the National Imaging Mapping Agency (NIMA) Blanket Order Agreement (BOA) (Space Imaging Corporation 2001). Such multiple-use licenses usually cost more. Euromap, the provider of IRS images, charges an additional 40 percent fee for data with special licensing requirements (Euromap 2001).

If funds become available for high-resolution data, states may need to identify priority data needs such as was done in the brainstorming session between MDEQ and NASA. These efforts would need to occur in order to identify locations in their respective states where imagery of this type would be particularly useful for multiple investigations.

In Louisiana, state agencies have applied another approach to increase spatial resolution of existing imagery. They have merged Landsat data with IRS data to create a background color IR map with 5-meter resolution. The agencies successfully updated their historical coverages with the new data for more accurate images. Annual workshops for remote sensors in the Gulf region would help to disseminate developments such as this, better enabling users throughout the region to better use their existing data.

Remote sensing imagery could greatly enhance on-going Gulf investigations. It is apparent that coordination amongst the users in the region is extremely important and that addition funds may help to coordinate region-wide workshops or data acquisition.

Overall Recommendations

- **Annual Region-Wide Workshops.** An annual workshop would provide an excellent venue for remote sensing users throughout the region to attend training sessions, to compare the latest developments in the field, and to define data areas of common interest. NOAAís CSC currently provides important training sessions. They have developed a 1.5 hour seminar entitled ìIntroduction to Remote Sensingî, which is designed as an overview of the costs and benefits of remote sensing and provides some basics on remotes sensing concepts and example applications. CSC is also in the process of developing a 2-day, hands-on training class entitled ìRemote Sensing for GIS professionalsî. The seminar intends to strengthen the link between GIS and remote sensing by providing remote sensing concepts and applications in order to demonstrate the full range of tasks from finding and ordering imagery through processing data and then incorporating the product into a GIS database. There may be additional needs for a workshop intended to gather all GIS and remote sensing users to discussing the latest developments in the rapidly evolving field.

- **State Brainstorming Sessions.** A large number of state representatives indicated that high-resolution imagery was one of their top data needs. Statewide brainstorming sessions, such as the one held between MDEQ and NASA, need to occur in order to identify priority locations where imagery from IKONOS or IRS is needed. The imagery can then be purchased under a multiple-user license to allow for its use by many investigators.

- **Data Sharing Methods.** Within each state, the remote sensing users should identify the most effective way to share data. As identified above, all state agencies rely on data sharing, however some of the Gulf States have established centralized agencies responsible for data purchasing, processing and dissemination. The data sharing strategy may differ, however it is important to establish a way for everyone to know what data is available and how to access it. State-specific web sites, similar to Louisianaís, may provide a location to identify accessible data and data needs.

5.0 ACKNOWLEDGEMENTS

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APPENDIX A
Questions Used to Structure Communication with Study Participants

The following five questions address the core of the information we are seeking on the use of remote sensing to address coastal environmental issues in the Gulf of Mexico region. The results of this study will be used to supplement information gathered in a prior national survey by the NOAA Coastal Services Center to assess use and needs of remote sensing to address U.S. coastal issues in the Gulf of Mexico region.

Use of Remote Sensing Technology at the State and Local Level

1. Which coastal issues do you currently address or hope to address in the future with support of remote sensing tools (*i.e.,* Habitat, Water Quality, Coastal Development, or Hazard Issues)

2. What remote sensing imagery, datasets, or tools are currently being used by you or your agency to address coastal environmental issues? Please briefly provide the following information for each specific application/program.

    - How do you obtain this remote sensing support (Source, point of contact, etc.)?
    - What management goals, questions or decisions are being aided by the remote sensing information and tools utilized?
    - Are there other state or federal agency partners that you or your agency use to obtain the remote sensing information you require?
    - Are there specific time periods or specific geographic areas of interest for your remote sensing requirements?
    - Who has access to your remote sensing information? If your information is available to the public, what level of public interest have you seen and what types of products are of public interest?

Barriers to Use of Remote Sensing Technology at the State and Local Level

3. Are there any barriers (administrative or technical) that limit your use of remote sensing technology? Please consider each step in your requirement which may include (a) obtaining the necessary information, (b) processing existing data or images, (c) analyzing the remote sensing data or images or (d) integration with other information and presenting the final results?

Priorities/Solutions at the State and Local Level

4. If you use remote sensing products or information, please identify and prioritize your unmet remote sensing needs (e.g., datasets, tools, products) to adequately address coastal environmental issues.

5. Are there areas of common interest across state or regional boundaries where a partnership with other users or agencies might assist you or reduce your costs in meeting your needs for remote sensing products and information?

APPENDIX B
Study Participant List

State	Individual	Affiliation
Florida	Chris Friel/Jim Burd	FMRI
Florida	Steve Dicks	SWFWMD
Florida	Randy Kautz	FWCC
Alabama	Carl Ferraro	ADEM
Alabama	Will Brantley	Baldwin County, Alabama
Alabama	Nick Tew	GSA
Mississippi	Mark Foster	MSDMR
Mississippi	Kay Meherg	MSDEQ
Louisiana	Bo Blackmon	LDNR
Louisiana	Blaire Hutchison	USGS
Louisiana	David Gisclaire	LOSCO
Louisiana	Paul Zundel	LDEQ (GIS Coordinator)
Louisiana	Dewitt Braud	LSU
Texas	Hugh Bender	TNRIS
Texas	Gary Powell	TWDB
Texas	Jeff Williams	TPWD

APPENDIX C
Glossary of Remote Sensing Terms

Advanced Very High Resolution Radiometer (AVHRR) - AVHRR data are collected via sensors aboard meteorological satellites operated by NOAA. The data are collected in visible, near-infrared, and thermal-infrared spectrums and then the EROS Data Center processes the data to approximately a 1-km resolution. The resultant information is then used for drought monitoring, fire fuel assessment, and land surface characterization (USGS[1] 2001).

Coastal Ocean Dynamics Applications Radar (CODAR) - CODAR uses electromagnetic waves of about 10 meters in length that interact with 5 meter long ocean waves enabling researchers to measure surface currents, waves and general circulation patterns (Rutgers University 2001).

Digital Ortho Quarter Quad Photos (DOQQs) ñ DOQQs are aerial photographs that have been ortho-rectified at a resolution of 1 meter. Digital orthophotos have a uniform scale, which makes it possible to overlay information, thus they serve as effective base maps (NCSU 2001).

EROS Data Center ñ USGSís data management, systems development, and research field center and the receiving station for Landsat data (USGS[2] 2001).

Hyperspectral Imagery - Images obtained from a discrete number of (narrower) bands, typically on the order of hundreds of bands.

IKONOS - A commercial high-resolution satellite that provides 1-meter Earth imagery. Space Imaging Corporation produced and first began to sell the imagery from IKONOS in January 2000 (Space Imaging Corporation 2001).

Indian Remote Sensing (IRS)- The latest IRS satellite was launched in 1997. India developed its satellite program in 1981 to provide information to its National Natural Resource Management Programs. The data is received and disseminated by several countries throughout the world (Federation of American Scientists 2001).

Landsat Thematic Mapper (TM) - A series of NASA satellites designed to provide repetitive global coverage of the Earth's land masses. Over 20 years of data has been collected from Landsat satellites, recording major characteristics or changes to the Earthís surface such as desertification, deforestation, pollution, cataclysmic volcanic activity, and other natural and anthropogenic changes. The newest Landsat Satellite, Landsat 7, collects 7 bands of the electromagnetic spectrum (USGS[3] 2001).

Light Detection and Ranging Technology (LIDAR) ñ A lidar system uses laser pulses to measure atmospheric constituents, and profiles of these atmospheric components as a function of altitude or location, which can be used for weather forecasting, climate modeling, and environmental monitoring. These systems can be used generate high-density, geo-referenced digital elevation data (DEMS) (NOAA 2001, Airbornelasermapping.com 2001).

Moderate Resolution Imaging Spectroradiometer (MODIS) - A NASA satellite with 36 spectral bands that views the entire Earth's surface every 1 to 2 days (NASA[1] 2001).

Multispectral Imagery ñ Images obtained from a discrete number of bands of the electromagnetic spectrum; typically 12 bands or less constitute multispectral imagery (ARMY 2001).

Orthophotos - Aerial photographs that have been ortho-rectified with ground elevation data to correct for terrain relief and camera angles (NCSU 2001).

Panchromatic Imagery - Black and white images obtained from a single band of the electromagnetic spectrum.

Sea ñViewing Wide Field-of-View Sensor (SeaWiFS) - The SeaWiFS project collects, processes, and distributes data received from an Earth-orbiting ocean color sensor. The project intends to provide quantitative data on global ocean bio-optical properties, therefore it tracks subtle changes in ocean color, which may signify various types and quantities of marine phytoplankton (NASA[2] 2001).

Side Scan SONAR- Side scan SONAR systems emit ultrasonic waves to locate objects and record the sea bottom. MDMR collects the its own imagery and uses it for artificial reef and derelict vessel management and monitoring (Marine Group 2001).

SPOT Image Corporation - Spot Image is a commercial vendor that distributes panchromatic and multispectral imagery from Earth Observation Satellites on a worldwide basis (SPOT 2001).

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APPENDIX D
DRAFT

MEMORANDUM OF UNDERSTANDING

BETWEEN THE

LOUISIANA
DEPARTMENT OF NATRUAL RESOURCES
DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF EMEGENCY PREPAREDNESS

U.S. GEOLOGICAL SURVEY
NATIONAL WETLANDS RESEARCH CENTER

AND THE

U.S. GEOLOGICAL SURVEY
EROS DATA CENTER

1. PURPOSE

This Memorandum of Understanding (MOU) sets forth the general terms and conditions by which the U.S. Geological Survey/National Wetlands Research Center, Louisiana-Department of Natural Resources, Department of Environmental Quality, Office of Emergency Preparedness collectively referred to as the Emergency/Disaster Geospatial Data Activity (EDGDA) and the U.S. Geological Survey/EROS Data Center (EDC), agree to cooperate in activities of mutual interest, such as geographic and cartographic data production, geospatial data standards, exchange of data, information, and products, emergency response and hazard mitigation efforts, earth science information and product dissemination, and research and applications projects, workshops, training, and technology transfer.

2. MISSION DEFINITION

The participants of the Louisiana Emergency/Disaster Geospatial Data Activity (EDGDA) are responsible and established by state and federal legislative authorities.

The Louisiana EDGA participants (Louisiana Department of Environmental Quality, Louisiana Department of Natural Resources, Louisiana Office of Emergency Preparedness and U. S. Geological Survey/National Wetlands Research Center) each provide leadership, technical services, and financial assistance to support planning, conservation, and responsible development of natural, water and social resources for the state of Louisiana and nearby coastal areas of the Gulf of Mexico. This is achieved collectively by providing funding to local governments for natural, water and social resources for conservation, treatment, supply and disaster control projects; development of regional plans; and maintenance of a geospatial and informational database clearinghouse.

The U.S. Geological Survey was created by Congress in the Organic Act of March 3, 1879 (20 Stat. 394, 43 U.S.C. 3) which provided for "the classification of the public lands and the examination of the geological structure, mineral resources, and products of the National Domain." Part of the U.S. Geological mission is to meet the Nation's need for basic (cartographic and digital) geospatial data, ensuring access to and advancing the applications of these data and other earth science information for users worldwide. This is being accomplished by ensuring the production and availability of basic cartographic and geographic spatial data of the country, coordinating national geospatial data policy and standards, providing leadership for the management of earth science data and for information management, acquiring, processing, archiving, managing, and disseminating the land remote sensing data of the Earth, and improving the understanding and application of geospatial data and technology.

3. SCOPE

This MOU serves as an umbrella agreement that sets forth the general terms and conditions under which the Louisiana EDGDA participants and the USGS/EDC will coordinate and cooperate in activities involving various aspects of geospatial and remote sensing data. The activities covered by this MOU will be of mutual interest within, but not limited to, the following areas:

a. Geographic and Cartographic Data Production – The EDGDA and EDC may cooperate data production and maintenance activities to support mutual requirements for U.S. map products and digital geospatial data and contribute to National Spatial Data Infrastructure and Framework concepts.

b. Digital Geospatial Data Standards – The EDGDA and EDC will work toward the goal of harmonizing data structures and standards, and flexibility in data formats to facilitate compatible environments between the two agencies.

c. Exchange of Topographic Information, Data, and Products – The EDGDA And EDC will work cooperatively in the exchange and reimbursement of published products and data. These include: standard topographic maps, imagery, digital products, information, data, and other releasable products and publications. The scope of this cooperative activity may be expanded by mutual agreement to include other EDGDA and EDC products not currently part of the exchange and reimbursement program.

d. Earth Science Information and Production Dissemination – The EDGDA and EDC will support the operation of an Earth Science Information Center (ESIC) that will be collocated with the University of Louisiana at Lafayette/NASA/Regional Applcations Facility and will cooperate as appropriate in the dissemination of USGS products through the USGS Business Partner Program.

e. Emergency Response and Hazard Mitigation – The EDGDA and EDC will Work cooperatively to provide appropriate products quickly in response to emergencies resulting from events such as tornadoes, hurricanes, wild fires, floods, earthquakes, drought, and spills. Longer-term collaborative efforts may address hazard mitigation strategies.

f. Research and Applications – The EDGDA and EDC may collaborate in the conduct of a broad range of research and applications project, and other activities of mutual interest. Example ?

g. Workshops, Training, and Technology - The EDGDA and EDC will Collaborate, when appropriate, on holding workshops, providing training, and the transfer of technology when appropriate and of mutual interest.

h. Outreach and Education – When appropriate, the EDGDA and EDC will Cooperate on joint outreach and educational activities.

4 RESPONSIBILITIES

a. The EDGDA and EDC will regularly provide updates on program activities, technology application, development and related work pertaining to cooperative activities pursued under this MOU through written correspondence, EDGDA/EDC coordination meetings, and other mechanisms.

b. EDGDA and EDC will provide leadership and program oversight of the cooperative activities conducted under this MOU through a joint EDGDA/EDC Strategic Partnership Committee. The Committee will review overall program Requirements and cooperative arrangements under this MOU at least annually. Through the joint EDGDA/EDC Committee, EDGDA and the EDC may establish work groups, review and approve group charters, work plans and reports, and resolve related issues when necessary.

c. EDGDA and EDC will review all existing agreements between each other with the intent to revise, consolidate, and/or incorporate as annexes to this MOU, where possible, such agreements pertaining to the areas of cooperation covered by the scope of this MOU. It will be the responsibility of the EDGDA and EDC to periodically review the effectiveness of these documents in relation to the subject MOU.

d. The specific interagency relationships and responsibilities with regard to the Cooperative activities covered under the scope of this umbrella MOU shall be further defined in annexes to this MOU.

e. Emergency Response Program at EDC will coordinate the acquisition and delivery of the first near cloud free satellite Landsat 7 image of a post hurricane, tornado, and flood event. The USGS, Center for Integration of Natural Disaster

Information (CINDI) will provide the cost support for acquisition of the first near cloud free satellite Landsat image of a post hurricane, tornado and flood event.

5 IMPLEMENTATION

a. Implementation of this MOU shall be supported by appropriate annexes and will be coordinated through mutual agreement between the (government agency(ies)) or their designated representatives. Annexes to this MOU will be coordinated with appropriate USGS offices and centers for review prior to signature.

b. As appropriate, annexes will include, at a minimum, the following:
(1) Description of product(s) and service(s) to be supplied, and projects;
(2) Legislative authorities;
(3) Agency responsibilities;
(4) Description of financial arrangements;
(5) Production and/or delivery schedules;
(6) Applicable standards and technical specifications;
(7) Duration of the plan/project; and
(8) Programmatic and/or technical points of contact.

6 FINNANCIAL ARRANGEMENTS

a. The EDGDA and EDC will, through direct appropriations, cost/work share, full reimbursement, or exchanges in kind, carry out the activities covered by this MOU. Performance of either party under the terms of this MOU is subject to the availability of appropriated funds and personnel resources through their respective funding procedures.

b. Both agencies agree that reimbursement payment will be on a service provided basis, calculated using mutually agreed upon prices.

7 EFFECTIVE DATE, PEROIDIC REVIEW, MODIFICATION, AND TERMINATION

This MOU shall take effect upon the date of the last signature. The EDGDA and EDC will conduct a formal review of this MOU at least every 5 years. Supporting annexes will be reviewed on a yearly basis, or sooner, as circumstances warrant. This MOU may be modified at any time upon joint approval. This MOU may be terminated at any time by mutual written agreement of the agencies, or by either agency upon 90 days written notice to the other agency.

8 POINTS OF CONTACT

The following individuals will be the points of contact for this MOU:

Paul Zendell

Louisiana Department of Environmental Quality
Director
Geographic Information Systems
Baton Rouge, La. 70884
Phone 225-765-0062
Email: paul_z@deq.state.la.us

James B. Johnston

U. S. Geological Survey
National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, La. 70506
Phone: 337-266-8503
Email: jimmy_johnston@usgs.gov

Michael Crane

U. S. Geological Survey
Eros Data Center
Sioux Falls, SD 57198
Phone: 605-594-6041
Email: mpcrane@usgs.gov

9 APPROVALS

Dale Givens

Executive Administrator
Louisiana Department of Environmental Quality
Baton Rouge, La. 70884
Phone: 225-765-0741
Email: dale_g@deq.state.la.us

Date

Robert E. Stewart, Jr.

Director
U. S. Geological Survey
National Wetlands Research Center
Phone: 337-266-8501
Email: bob_stewart@usgs.gov

Don Lauer

Director
U. S. Geological Survey
Eros Data Center
Sioux Falls, South Dakota
Phone: 605-594-6154
Email

Thomas Casadevall

Director, Central Region
U. S. Geological Survey
Denver Federal Center
Denver, CO 80225
Phone: 303-202-4740
Email: tcasadev@usgs.gov

Date

APPENDIX E
Results of NASA/MDEQ Brainstorming and Prioritization Session Held in December 2000

Complete List

1. (5 and 6) Identification of abandoned surface mines or illegal mines with focus on off-site sedimentation. 1ACRE; MONTHLY. Current surface mines, expand, where to expand to, off-site sedimentation Illegal construction activities causing run-off and sedimentation. CURRENT <5 ACRES, 1 ACRE. MONTHLY
2. (33) Help with applications of surface geologic mapping (clay, sand, etc) detailed mapping of eco-region concept support. Areal distribution of eco-region varies geology and physiography and climate. BEST AVAILABLE REGIONAL AND YEARLY. LAND USE NW MS aquifer serves multi-state area; urbanization in area, rate aquifer loss or growth will drastically change, need to quantify that; total outcrop area; YEARLY INVENTORY AT A MINIMUM
3. (37 and 42) Microseepage (natural and anthropogenic); HIGH RESOLUTION Identification of stressed vegetation especially along pipelines etc. Micromagnetic survey, airborne, low altitude; locate infrastructure, pipelines in the state, leaks. HIGH RESOLUTION
4. Identify estimate in MS delta land use categories; Water use, including NE delta land, catfish farms. Annually with high level of accuracy. LU TYPES OF CROPS; 1-5 ACRES; ANNUALLY.
5. Dam safety, easy way to assess land use below the dams; change in inventory, change in water use; inventory of high hazard dams is badly needed and hard to do efficiently with available resources. LAND USE; WATER BODY 5 + ACRES; ANNUALLY; STRUCTURE MAY BE LESS THAN AN ACRE
6. (29 and 36) Stream conditions under difficult flow regimes, surface water withdrawal sites, regulation of waterways (as they get blocked; status changes.; WEEKLY, 10í TO RIVER SIZE. Low flows critical in surface water basins. Can we identify in various reaches in streams in basins, which are going dry in May-November; we can identify the impact on basin specifically where base flow is getting into the system. Identify aquifers ground water monitoring, sources of base flows identified which allows better forecasting Optimal use of remote sensing in measuring stream flow, lake levels. **PRIORITY 1**
7. (11 and 28) Land use changes over time in general, land fill siting, pinpoint areas of greatest change. 20-40 ACRE; BASELINE LAND USE, Land use: latest data set DEQ now has is 1993; criticized for using old data; need more current land use information, priority data; LANDSAT priority areas Land use! Current, accurate, including accurate elevations; determine level of accuracy

8. (30) Identify pollutants in urban communities; outreach initiatives, incentives and restorations for air, water, and land pollution.. Land Use related to environmental justice, especially near residential areas. LAND USE; BASELINE, 5 YEARS 1 ACRE
9. (18 and 21) Identify and quantify pollutant loading for TMDL development., VARIABLE SPATIAL RESOLUTION MODELS, TIME TO IMPLEMENT 5-10 YEARS. Detail land use, riparian zone analysis; non-point source pollution; specific crop types, pesticide use; septic tanks. Level III and better. Land us, ability to identify trends related to water quality and impairment
10. Find way to identify ownership and land use. COUNTY ISSUES, GIS
11. (27) Identify areas where recent burials may occur from 5 drums to large burials., HIGH RESOLUTION AS NEEDED. Ways to determine surface, subsurface contamination, identify waste dumps, hazardous waste sites
12. Build on meteorological and air quality model for Coast; assist on ozone forecasting (more accurate). HIGH RESOLUTION, COUNTY LEVEL.
13. Data used to develop and better allocate major mobile and area pollution sources and emissions sources; non-point source. LAND USE ACTIVITY MODELS; 40+ ACRES. 3 YEARS.
14. (20) Coastal erosion and morphology changes; LIDAR data; combine data to develop morphology models; LAND USE 10 METER; MONTHLY; AS HIGH AS 1í 6î Elevation map of the state, 1í-6î contour.
15. Mitigation monitoring; inspecting endangered species habitats, wildlife corridors; illegal construction activities in the wetlands; LAND USE DAILY, 1 ACRE, BI-WEEKLY, MONTLHY.
16. (26 and 31) Identify technical infrastructure and technology tools to support these projects. Web hosting for spatial data that can be downloaded exchanges, including metadata Data management system being started, how can this data be incorporated or interface; awareness of it being developed
17. Identification of and impact from animal waste application sites. LAND USE, 1 ACRE, SEASONAL.
18. Nutrient load estimates of lakes and perennial streams; algae blooms; turbidity; SEASONAL, ANNUAL, 1 ACRE.
19. Naturally occurring air pollutant sources in state; quantity location timing and frequency. 3 YEAR CYCLES; 40 ACRES
20. Change detection; capability to look at industrial expansion/growth and compare to previous period; new stacks, building expansions, planning purpose require quick turn-around. WEEKLY, HIGH RESOLUTION.
21. Change of vegetation in hill section is drastic; change to Pine Plantations which consume a lot more water than native species will we see a drop in stream base flow due to vegetation changes especially in outcrop areas. LAND USE, 5 YEAR, 50-100 ACRES TO SQUARE MILES.

22. (47) Storm water phase II requirements, planning, measure effectiveness, measure environmental improvements, environmental impacts;, LAND USE; BASELINE, 1 ACRE, ANNUAL. Modeling of development along the coast to be extended statewide
23. GIS Fish Advisory in streams lakes; contaminant plumes.
24. Identify sand/gravel aggregate location and resources for resource management and land use planning. LAND USE; BASELINE; 4-5 ACRES.
25. EPA Gulf of Mexico and DMR partnerships.
26. Location of offshore fresh water spring discharges. 1 ACRE, BASELINE, SUMMER, THERMAL.
27. Measure contaminants in the air, water, and soil remotely.
28. (46) Identify mercury deposition, air sources? Can we look at stacks as potential sources, Targets? Plume tracking;, BSELINES, SEASONAL, METERS TO MILES. Air borne transports of air pollution, state to state; plume tracking
29. Point geochemical study done: can it be replicated using remote sensing? (10 km grid). Consisted of elemental analysis of 50 chemicals in the soil. 30 METER; 1 TIME.
30. Change detection: MEMA, hurricane/ice storm; before and after assessment of impact; save time and money; identify areas ahead of time to get snap shot. VARIABLE, 1-30 M; AS NEEDED; BASELINE 6 MONTHS TO 2 YEARS.
31. Better understanding of earthquake risks in NW MS. Look for evidence as in sand blows. Stressed vegetation important in earthquake predictions. 1 ACRE TO SEVERAL ACRES; BASELINE FOR SAND BLOWS.
32. Inventory of data that NASA has, Digital Earth Model Discussion. NASA ACTION.

Priorities

Priorities were selected by multi-voting, using two weighted criteria, urgency and pervasiveness.

1. Stream conditions
2. Water pollution
3. Land use/land cover ñ annually at the Mississippi Delta
4. Air pollution
5. Abandoned mines
6. Land use/land cover ñ baselines, siting, sand/gravel